

## APPARATUS FOR ENCODING AND INDEXING

### BACKGROUND

An apparatus may make use of one or more moveable elements. It may be helpful to determine a current location of a moveable element during operation 5 of such an apparatus. Encoding and indexing may be employed to assist in the determination of the current location of the moveable element. Improving either the encoding mechanism, the indexing mechanism, or both may contribute to reducing the cost of making the apparatus.

An example of such an apparatus is an imaging system. An example of a 10 moveable element of an imaging system is a pen assembly of the imaging system.

### BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will be described referencing the accompanying drawings in which like references denote similar elements, and in 15 which:

**Figures 1a-1c** illustrate cross section views of an arrangement in accordance with different embodiments of the present invention;

**Figures 2-3** illustrate a “top” exposed view of the code wheel, and a “side” isolated view of the light source of the embodiments in **Fig. 1a-1c** in further detail 20 respectively;

**Figure 4** illustrates a cross section view of another arrangement in accordance with another embodiment of the present invention;

**Figure 5** illustrates a “top” exposed view of the code wheel of the embodiment in **Fig. 4** in further detail;

25 **Figures 6a-6c** illustrate cross sections views of yet another arrangement in accordance with yet other embodiments of the present invention;

**Figures 7a-7c** together illustrate a “top” exposed view of each of two other code wheels in further detail;

30 **Figures 8a-8b** together illustrate a cross section view of yet another arrangement in accordance with another embodiment of the present invention;

**Figures 9a-9b** illustrate two signals output by the sensors of **Fig. 8a-8b** for the code wheel embodiments of **Fig. 7b-7c** respectively; and

**Figure 10** illustrates an example imaging system incorporated with the teachings of one embodiment of the present invention.

5        **DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION**

Embodiments of the present invention include, but are not limited to a sensor for encoding and indexing, a companion code wheel, and arrangements and/or imaging systems endowed with these elements.

In the following description, various aspects of embodiments of the present  
10 invention will be described. However, it will be apparent to those skilled in the art that embodiments of the present invention may be practiced with only some or all aspects described. For purposes of explanation, specific numbers, materials and configurations are set forth in order to provide a thorough understanding of these embodiments of the present invention. However, it will be apparent to one skilled  
15 in the art that various embodiments of the present invention may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order not to obscure the disclosed embodiments of the present invention.

The phrase "in one embodiment" is used repeatedly. The phrase  
20 generally does not refer to the same embodiment, however, it may. The terms "comprising", "having" and "including" are synonymous, unless the context dictates otherwise.

Referring now to **Figures 1a-1c** wherein cross sectional views of an arrangement, in accordance with different embodiments of the present invention  
25 are shown. As illustrated, the arrangement includes sensor assembly **200** and code wheel **300** for encoding and sensing. Axis **308** is the axis of a rotate-able shaft which current angular position is to be determined employing sensor assembly **200** and code wheel **300**.

Sensor assembly **200** includes portion **200a** and portion **200b**. Portion  
30 **200a** includes light source **202**, while portion **200b** includes sensors **204a** and

**204b.** Light source **202** emits collimated light rays **206a-206c**. In various embodiments, sensors **204a-204b** are comprised of photocells.

However, portions **200a** and **200b** are offset and has a width ( $w_1$ ) that is smaller than span ( $s_1$ ) of encoder and index tracks **302-306**.

5 Further, light source **202** does not emit collimated light rays **206a-206c** orthogonally towards sensors **204a-204b**. Instead, light source **202** emits collimated light rays **206a-206c** angularly towards sensors **204a-204b**.

As will be described in more detail below, for the embodiment, transparent windows of encoder track **302** and index tracks **304-306** are either formed with

10 materials having appropriate complementary refraction indices or coated with materials to provide the transparent windows with the appropriate complementary refraction indices, such that when the transparent windows pass underneath light source **202**, angularly emitted collimated light rays **206a-206c** are refracted **208a-208c** onto sensors **204a-204b**, and thus, may be sensed by sensors **204a-204b**.

15 Further, the transparent windows of encoder track **302** and index tracks **304-306** may be of different shapes, including non-rectangular shapes.

For the embodiment of **Fig. 1a**, the “smaller” portions **200a-200b** are “offset” in favor of encoder track **302**. Accordingly, light source **202** emits all collimated light rays **206a-206c** towards sensors **204a-204b** with increasing deviation angles (relative to the orthogonal direction) from collimated light rays **206c** to collimated light rays **206a**. That is, relative to the orthogonal direction, collimated light rays **206b** have larger deviation angles when compared to collimated light rays **206c**, and collimated light rays **206a** have larger deviation angles when compared to collimated light rays **206b** and **206c**.

25 In contrast, for the embodiment of **Fig. 1b**, the “smaller” portions **200a-200b** are “offset” in favor of index track **306**. Accordingly, light source **202** emits all collimated light rays **206a-206c** towards sensors **204a-204b** with increasing deviation angles (relative to the orthogonal direction) from collimated light rays **206a** to collimated light rays **206c**. That is, relative to the orthogonal direction, collimated light rays **206b** have larger deviation angles when compared to

collimated light rays **206a**, and collimated light rays **206c** have larger deviation angles when compared to collimated light rays **206a** and **206b**.

For the embodiment of **Fig. 1c**, portion **200a** also includes mirrors **203a-203b**. The “smaller” portions **200a-200b** are substantially “centered” over index track **304**. Accordingly, light source **202** emits collimated light rays **206b** orthogonally towards sensors **204a**. Collimated light rays **206a** and **206c**, on the other hand, are emitted angularly away from sensors **204a-204b** (relative to the orthogonal direction), and reflected by mirrors **203a-203b** to pass through transparent windows of index and encoder tracks **306** and **302** respectively. As before, collimated light rays **206a** and **206c** are then refracted onto sensors **204a** and **204b**.

**Figure 2** illustrates code wheel **300** in further detail in accordance with one embodiment. Code wheel **300** includes encoder track **302**, and index tracks **304-306**, each having a number of transparent windows, except in the case of index track **306**, a single transparent window. As described earlier, appropriate ones of the transparent windows (depending on the dispositions of the different portions of sensor assembly **200**) are either advantageously formed or coated with materials that provide the transparent windows with the appropriate complementary refraction indices to refract collimated light rays **206a-206c** emitted by light source **202** onto sensors **204a-204b**. Further, the transparent windows may be of different and non-rectangular shapes.

The appropriate refraction indices depend on the relative positioning between the “smaller” sensor assembly **200** and the encoder and index tracks **302-306**. Any one of a number of materials or combination of materials may be employed to provide the desired refraction indices.

**Figure 3** illustrates light source **202** in further detail, in accordance with one embodiment. As illustrated, light source **202** includes light emitting diode (LED) **322** and lens **324**. Lens **324** include a number of portions, having different refraction indices, a first refraction index for a first portion, a second refraction index for a second portion, and so forth, to enable collimated light rays **206a-206c** to be emitted with the desired angles of deviation.

In alternate embodiments, light source **202** may employ more than one LED.

Referring back to **Fig. 1a-1c**, thus a modulation signal, and in turn, an index pulse useable to assist the determination of a current location of a

- 5 moveable element of an apparatus during operation, may be generated, but with the ability to employ a “smaller” sensor assembly **200**. The ability to employ a “smaller” sensor assembly **200** contributes towards freeing up the otherwise occupied space for use by other components to provide additional functions, or contributes towards enabling smaller, more compact, and possibly less costly  
10 systems to be built.

While the embodiments of the **Fig. 1a-1c** have been described with selected ones of collimated light rays **206a-206c** being emitted with deviation angles (relative to the orthogonal direction) towards sensors **204a-204b**, and the emitted light rays being refracted onto sensors **204a-204b** as the transparent  
15 windows of encoder and index tracks **302-306** pass “underneath” light source **202**, alternate embodiments, may also be practiced with angularly emitted light rays **206a-206c** passing through corresponding ones of transparent windows of encoder and index tracks **302-306** before or after they passed “underneath” light source **202**. These embodiments may be practiced with emitted light rays **206a-**  
20 **206c** not only having deviation angles in the plane where **Fig. 1a-1c** are illustrated, but also in another plane orthogonal or otherwise intersect with the plane of **Fig. 1a-1c**.

Further, as illustrated, portions **200a** and **200b** may be different portions of a single housing. That is, the single housing includes a common portion **205**  
25 joining portions **200a** and **200b**. In various embodiments, circuitry in support of modulating a signal based on the amount of light rays sensed by sensors **204a-**  
**204b** and generating the index pulse when the modulated signal sensed by sensors **204a** exceeds a threshold, may be disposed in common portion **205** joining portions **200a** and **200b**.

30 Additionally, the embodiments of **Fig. 1a-1c** have been described referencing code wheel **300** of **Fig. 2** with the index tracks **304-306** being

disposed "inside" of "outermost" encoder track 302. Alternate embodiments may also be practiced with other disposition arrangements, including but are not limited to having either or both index tracks 304-306 being disposed "outside" of encoder track 302, as well as having only one index track.

5        Further, while the embodiments of **Fig. 1a-1c** have been described referencing code wheel 300 of **Fig. 2**, code wheel 300 may also be referred to as a code sheet having a wheel like form factor with the earlier described tracks of transparent windows disposed thereon. Alternate embodiments may be practiced with code sheets of other form factor. In particular, alternate  
10      embodiments may be practiced with a code sheet having a linear form factor for assisting in determining a current location of a moveable element that moves linearly (as opposed to angularly, in the case of a shaft). Technically, a linear moving element can be considered as a special angular moving element, where the radius that defines the "orbit" of movement is "infinite" in length.

15      **Figures 4 and 5** illustrate another embodiment of the present invention. Again, **Fig. 4** illustrates a cross sectional view of an arrangement to assist in determining a current location of a moveable element of an apparatus. The arrangement includes sensor assembly 400 and code wheel 500. The arrangement is illustrated in the context of using sensor assembly 400 and code  
20      wheel 500 to determine a current angular position of a rotate-able shaft, which axis is depicted as axis 508 in **Fig.4-5**.

25      Sensor assembly 400 includes two portions 400a and 400b, with portion 400a having light source 402 and portion 400b having sensors 404a-404b. Dimension wise, sensor assembly 400 is substantially that of the "smaller" embodiments of **Fig. 1a-1c**, i.e. having width (w1). However, sensor assembly 400 is employed with code wheel 500, where one of the index tracks, more specifically, index track 504 is a partial ring. Further, index track 504 is "merged" with encoder track 502. That is, the transparent windows of index track 504, in addition to being formed with or coated with materials, as appropriate, to refract  
30      collimated light rays 506b onto sensors 504a, the transparent windows of index track 504 are interleaved with a subset of the transparent windows of encoder

track **502**. Accordingly, for the embodiment, the span (s2) of encoder and index tracks **502-506** is substantially equal to the width (w1) of portions **500a** and **500b**.

For the embodiment, light source **402** is substantially “centered” over sensors **404a-404b**. Thus, unlike the embodiments of **Fig. 1a-1c**, light source

- 5   **402** emits light rays orthogonally towards sensors **404a-404b**. Accordingly, only the transparent windows of index track **504** are formed or coated with materials to provide an appropriate refraction index. The transparent windows of encoder track **502** and index track **506** may be conventionally formed.

Nevertheless, because span s2 is smaller, for a given technology or  
10 process in making code wheel **500** with transparent windows of a particular dimension (precision), code wheel **500** is advantageously more compact (smaller) than code wheel **300**. Accordingly, the overall dimension of the arrangement of **Fig. 4** may be even smaller than the overall dimension of the arrangement of **Fig. 2**.

15   **Figures 6a-6c** illustrate yet other embodiments of the present invention. Again, **Fig. 6a-6c** illustrate cross sectional views of an arrangement to assist in determining a current location of a moveable element of an apparatus. The arrangement includes sensor assembly **600** and code wheel **500**. Again, the arrangement is illustrated in the context of determining a current angular location  
20 of a rotate-able shaft, which axis is depicted as axis **508**.

Similar to the embodiments of **Fig. 1a-1c**, sensor assembly **600** includes two offset portions **600a** and **600b**, with portion **600a** having light source **602** and portion **600b** having sensors **604a-604b**. Similar to the embodiments of **Fig. 1a-1c**, light source **602** emits collimated light rays **606a-606b** angularly deviated from the orthogonal direction. However, for these embodiments, light source **602** merely emits two bundles of collimated light rays **606a-606b** with angular deviations. Also similar to the embodiments of **Fig. 1a-1c**, angularly emitted collimated light rays **606a-606b** are refracted onto sensors **604a-604b** for sensing, by the transparent windows of encoder and index tracks **502-506** with appropriate refraction indices. Thus, when used with sensor assembly **600** of  
30 **Fig. 6a-6c**, one or both of the transparent windows of encoder track **502** and

index track **506** may also be formed or coated with materials to provide appropriate refraction indices (in addition to the transparent windows of index track **504**).

Thus, sensor assembly **600** is essentially sensor assembly **200** further  
5 shrunk to the dimension of the width (w2) of a single track of code wheel **500**. Accordingly, the embodiments of sensor assembly **600** may be as small as half of the dimension of sensor assemblies **200** and **400** of **Fig. 2** and **4** respectively, providing a very compact arrangement solution for determining a current location for a moveable element in an apparatus, during its operation.

10       **Figures 7a-7c** together illustrate two embodiments of yet another code wheel **700**. As illustrated, code wheel **700** includes only one track **702** of transparent windows that serve as an encoder track as well as an index track. The transparent windows of track **702** are non-uniformly distributed, in that while virtually all portions (e.g. portion **704b**) of tracks **702** are approximately 50-50  
15 balanced between transparent window areas and non-transparent areas (the areas not having transparent windows), portion **704a** of track **702** is either configured to allow more lights to pass through, e.g. with more transparent windows (portion **704aa** of **Fig. 7b**), or configured to allow less lights to pass through, e.g. with less transparent windows (portion **704ab** of **Fig. 7c**). The  
20 areas enclosed by the dotted lines **706** in **Fig. 7c** depict the areas where transparent windows would have been provided in a uniformly distributed, 50-50balanced configuration.

Note that in alternate embodiments, the transparent windows may have non-rectangular shapes. The transparent windows may also be simply openings.

25       **Figures 8a-8b** together illustrate a cross section view of code wheel **700** in conjunction with another sensor assembly **800**. As illustrated in **Fig. 8b**, the cross sectional view of code wheel **700** and sensor assembly **800** is the cross section along the Y-Y axis depicted in **Fig. 7a**. As before, sensor assembly **800** includes two portions **800a** and **800b**. Portion **800a** includes light source **802**,  
30 whereas portion **800b** includes a linear array of sensors **804** (see also **Fig. 8a**).

For the illustrated embodiment, sensors **804** are configured to sense lights for both encoding and indexing, without partitioning the sensors **804** into two groups, a group to sense light rays for encoding, and another group to sense light rays for indexing.

- 5        Light source **802** emits light rays **806** orthogonally towards sensors **804**. Thus, the amount of light sensed by sensors **804**, and the signals in turn output by sensors **804** are as illustrated by the signals **900a** and **900b** of **Fig. 9a-9b** (corresponding to the code wheel embodiments of **Fig. 7b-7c** respectively). As depicted, signal **900a** reflects more light being sensed (peaks **902a**) when portion  
10      **704aa** passes underneath light source **802** (as compared to other portions of track **702**), whereas signal **900b** reflects less light being sensed (peaks **902b**) when portion **704ab** passes underneath light source **802** (as compared to other portions of track **702**). [Note that signals **902a** and **902b** are not illustrated to any scale, and the number of peaks are merely exemplary for illustrative purpose  
15      only. In practice, the signals outputted by the sensors may be analog or digital signals.]

Thus, by virtue of the changes in the peaks of signals **900a-900b**, the signals may in turn be processed (e.g. by software hosted by a controller or dedicated hardware (not shown)) to output corresponding derivative signals for  
20      encoding and indexing.

In alternate embodiments, sensors **804**, in addition to being linearly arranged as shown in **Fig. 8a**, may be configured with the sensors disposed at the ends adapted to sense the light rays for indexing, while other sensors adapted to sense the light rays for encoding.

25        In other words, by virtue of a single optical diameter for both encoding and indexing, code wheel **700** may be further made smaller as compared to the earlier described embodiments.

30        **Figure 10** illustrates an example imaging system incorporated with at least some of the teachings of the earlier described embodiments of an arrangement for assisting in the determining of a current location of a moveable item. As illustrated, for the embodiment, imaging system **1000** includes

processor/controller 1002, memory 1004, imaging engine 1006 and communication interface 1008 coupled to each other via bus 1010. Imaging engine 1006 comprises one or more moveable elements 1024, such as a pen assembly, and one or more corresponding position sensor arrangements 1026 to 5 sense a current location of a corresponding one of the moveable elements 1024.

Memory 1004 is employed to store instructions and/or data, more specifically, imaging control logic 1022. Imaging control logic 1022 is employed to control imaging of images including sensing of the current locations of the various moveable elements 1024 at different points in time during operation, 10 using position sensor arrangements 1026.

In alternate systems, application specific circuits (ASIC) may be employed in lieu processor/controller 1002 and memory 1004 having imaging control logic 1022.

Similarly, except for position sensor arrangement 1026, processors 1002, 15 memory 1004, imaging engine 1006 (including moveable elements 1024), communication interface 1008, and bus 1010 all represent corresponding broad ranges of such elements.

Position sensor arrangement 1026 may be any one of the earlier described sensor arrangements. In various embodiments, position sensor 20 arrangement 1026 is the arrangement of **Fig. 8a-8b**, using one of the code wheels of **Fig. 7a-7c**. For some of these embodiments, imaging control logic 1022 is further equipped to process the output signals of 900a/900b to generate corresponding signals for encoding and indexing. In other ones of these embodiments, dedicated hardware (not shown) is further provided to imaging 25 system 1000 to process the output signals of 900a/900b to generate corresponding signals for encoding and indexing.

In various embodiments, imaging system 1000 may be an inkjet printer or an electrophotographic printer.

Thus, it can be seen from the above descriptions, embodiments of a novel 30 arrangement to determine a current location of a moveable element of an apparatus has been described. While the novel method has been described in

terms of the foregoing embodiments, those skilled in the art will recognize that the method is not limited to the embodiments described. The method may be practiced with modifications and alterations within the spirit and scope of the appended claims.

- 5        Thus, the description is to be regarded as illustrative instead of restrictive.